

盘江矿区煤层气项目招商报告

# Investment Opportunities in Coal Mine Methane Projects in Panjiang Mining Area



United States Environmental Protection Agency



China Coalbed Methane Clearinghouse

April 2001 Beijing



Chairman: Zhang Shixin



President: Zheng Hua

Dear Colleague,

Panjiang Coal & Electric Power Group Co., Ltd. is located in the western part of Guizhou province. Since its establishment in 1966, this company has developed into one of the 520 most important enterprises in China. Now, the total assets of this company are over 4.0 billion yuan and its employees over 25,000. The company has been granted with "AAA" grade in credibility with the bank.

With a total area of 649km<sup>2</sup>, there are 6 active mines in Panjiang mining area. The total designed capacity of the mines is 8.55 Mt/a and the actual coal production is about 6.0 Mt/a. According to the overall development plan for Panjiang mining area, coal production capacity will be increased up to 15.0 Mt/a by the year 2008.

Coalbed methane resources are rich in Panjiang mining area, with total resources of 124.3 billion m<sup>3</sup> and gas content at 10~20 m<sup>3</sup>/t. 10 gas drainage systems have been constructed with total drainage capacity over 150.0 million m<sup>3</sup>/a. The actual drainage in the year 2000 was 42.0 million m<sup>3</sup>. However, only about 2.0 million m<sup>3</sup> of coalbed methane drained is utilized. Presently, the main use options of CMM in Panjiang include town gas and power generation. Push the

implementation of CMM use projects, a total of 35.0 million yuan of loan with discounted interests has been approved by Guizhou provincial government.

With the development strategy of coal mining as the core business and diversified economy sharing equal importance, coalbed methane development and utilization has become one of the most important areas of the diversified economy of the company. With the well-established coalbed methane drainage systems and very rich experiences in residential use of coalbed methane, Panjiang coal mining area will surely have brighter future and promising prospects in coalbed methane development and utilization. Investors from all over the world are welcome to come here for investigation and talks with Panjiang Coal & Electric Power Group Co., Ltd. for cooperation in CMM projects in Panjiang coal mining area.

Sincerely,

Zhang Shixin  
Chairman, Panjiang Coal & Electric Power Group Co., Ltd.

# Executive Summary

## Background

Panjiang Coal & Electric Power Group Co. (PCEPG) is one of the 520 largest industrial enterprises of China and it is also the largest coal mining company in the southern part of this country. Coal resources in the Panjiang mining area are estimated at nearly 48 billion tons, and coalbed methane resources in the area are estimated at 124.3 billion m<sup>3</sup>. Present actual coal production from Panjiang's six mines is about 6 million t per year (Mt/a). According to PCEPG's development plan, total annual coal output of the company will surpass 10 Mt/a by 2005 and reach 21 Mt/a by 2010.

All mineable coal seams in Panjiang mining area are gassy, with gas content ranging from 10 - 20 m<sup>3</sup>/t. Total methane emissions from the six mines are as high as 200 million m<sup>3</sup> per year, and emissions are increasing. Along with the expansion of coal production and the commissioning of new mines, total coalbed methane emissions will increase considerably. According to available geological data and drilling data, coalbed methane drainage could be increased to over 500 million m<sup>3</sup>/a if underground drainage and surface drainage were carried out simultaneously.

## Investment Opportunities

Presently, less than 5% of all methane drained is utilized, but PCEPG wishes to make full use of its coalbed methane in order to profit from gas sales and gas fired power generation. Following is a summary of the two potential CMM utilization projects for which PCEPG is seeking investment:

- 1) *Supply CMM to households, and to supplant coal at an existing power plant.* This project would use CMM to replace coal as a residential fuel, and would replace the use of medium heating value coal in the existing Laowuji power plant as well as the diesel oil that is currently used for ignition. The Guizhou Provincial Economic and Trade Commission has already provided a total of 35.0 million yuan (\$US 4.217 million) in the form of a low-interest rate loan to execute this project. PCEPG is seeking an additional 37.8 million yuan (\$US 4.554 million) from other investment or financing sources to undertake this project. Based on a total investment of 112 million yuan (\$US 13.494 million), the estimated net present value (NPV) of this project would be 42.9 million yuan (\$US 5.181), the estimated internal rate of return (IRR) would be 19.33%, and the payback time would be 6.04 years. PCEPG proposes to begin the project in 2001 Year and anticipates that it would be fully implemented by 2003 year.
- 2) *CMM power generation project* This project entails the construction of two CMM-fueled demonstration power plants. A proposed 9 MW plant at the Laowuji mine will consume 64,800 m<sup>3</sup> of CMM per day. A proposed 2 MW plant at the Tucheng mine will consume 14,400 m<sup>3</sup> of CMM per day. The mines will consume the generated power. Total cost of the project is estimated at 75 million yuan (\$US 9.036 million). Of this total, PCEPG would

provide 35%, and is seeking the remaining 65% from outside investment or financing sources. Based on the total investment of 75 million yuan (\$US 9.06 million), the estimated NPV of this project would be 23.3 million yuan (\$US 2.807 million), the estimated IRR would be 22% and the payback time would be 7 years. PCEPG proposes to begin the project in 2001 year and anticipates that it would be fully implemented by 2002 year.

PCEPG recognizes that investment in these projects entails certain inherent risks, such as potential fluctuations in CMM and electricity sales prices, and is prepared to help potential investors address these concerns. PCEPG can also answer questions about other important issues such as repatriation of profits.

PCEPG will consider various types of partnerships and financing sources in order to realize the proposed projects. Representatives of banks, foreign companies, foreign governments and international agencies are encouraged to review the attached marketing package and contact us for more information:

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## 1. Overview

The Panjiang mining area is located in the southwest part of Guizhou province. The total mining area covers 649 km<sup>2</sup>, containing an estimated 47.9 billion t of coal reserves. Most of the coal reserves in the mining area are bituminous with medium volatile matter. The coal deposit has a strong capacity for gas generation and storage. The mining area contains abundant coal mine methane (CMM) resources. Total estimated CMM resources buried shallower than 500 m are 124.3 billion m<sup>3</sup>. For the purpose of coal mine safety, a well-equipped CMM recovery system has been established in each coal mine in the Panjiang mining area. The total capacity of gas recovery is estimated at 150 million m<sup>3</sup>/a. At present, due to a shortage of gas utilization facilities, CMM recovery is at a minimum level. Pure methane recovery in 2000 reached 42 million m<sup>3</sup>, but less than 2% of the recovered methane was utilized.

Based on the market situation, CMM household use and power generation are the most realistic options for CMM utilization in the Panjiang mining area. Therefore, Panjiang Coal & Power Group Co. Ltd. is planning to establish a comprehensive CMM utilization project and a CMM power generation project.

The proposed Panjiang CMM comprehensive utilization project is based on local gas supply and market demands, plans for gas supply and distribution, and the sale of recovered gas to achieve the full utilization of CMM resources. This project will provide 163.7 million m<sup>3</sup> of commodity methane annually. The service life of the project will be 18 years.

Following household use, the comprehensive utilization project would use surplus gas to fuel two CMM power plants with a total installed capacity of 11 MW. The mining area would use all of the electricity generated in the two power plants. This project will use 23.76 million m<sup>3</sup> of methane annually, and project life will be 20 years.

These two projects will be planned and implemented by Panjiang Coal & Power Group Co. Ltd., as a commercial project. Results of a preliminary financial analysis are shown in Table 1.

**Table 1. Results of Financial Analysis for the Coal Mine Methane Utilization Projects in Panjiang Mining Area**

Project	Total Investment (million yuan)	Operating Costs (million yuan)	Sales revenue (million yuan)	IRR (%)	Pt (year)
CMM Comprehensive Utilization	103.47	28.55	58.93	19.33	6.04
CMM Power Generation	75.0	11.88	24.91	22	7

## 2. Introduction to the Enterprise

The predecessor of the Panjiang Coal & Power Group Co. Ltd. (PCPGC) was Panjiang Coal Mining Administration, which was established in 1966. After more than 30 years' development

and construction, PCPGC has developed and become a large state-owned industrial enterprise. PCPGC's main business is coal production, and other businesses include coal mine construction, civil engineering and installation, geological exploration, coal washing and preparation, building materials, and power generation. At present, the annual raw coal output of the enterprise is about 5 Mt. Its annual coal output ranks first among coal enterprises in the southwest provinces.

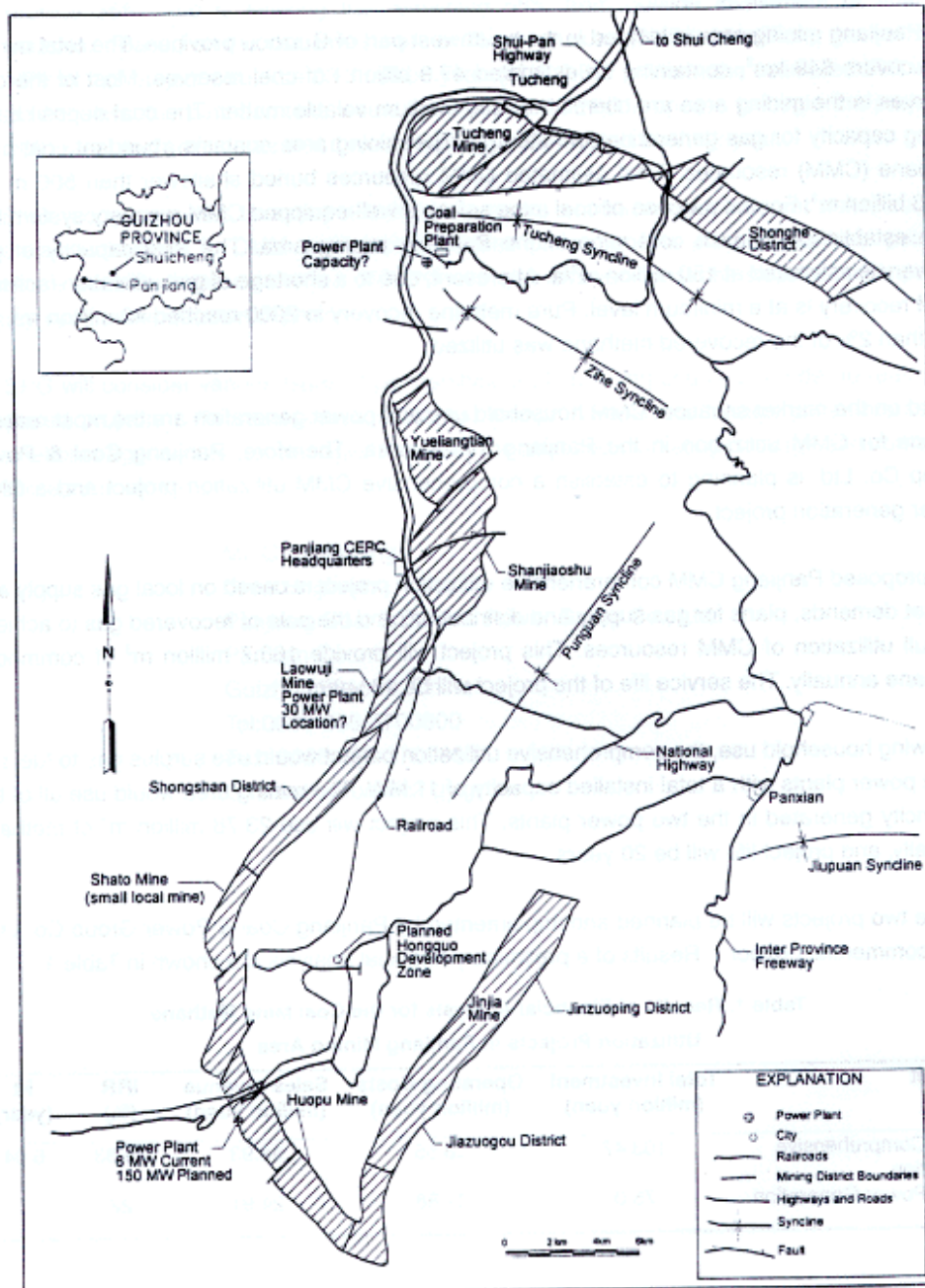


fig.1 Pangjiang mining area

Currently, PCPGC has 6 active coal mines and 3 coal washing plants. Designed capacities of raw coal production and coal washing & preparation are 8.55 million t (see Table 2). Limited by

the capacity of the railway transportation, the actual coal output has been around 5 million t. To increase the capacity of coal transport, the Nan-Kun railway (from Nanning to Kunming) is now under construction and is planning to be put into operation by 2002. Thus, PCPGC is planning to set up two new coal mines. Raw coal production is expected to increase to 21.4 million t by the year of 2015 (see Table 3).

**Table 2. The Designed Capacity of Coal Mines in Panjiang Mining Area**

<b>Coal Mine</b>	<b>Production Capacity (<math>10^5</math> t/a)</b>
Tucheng	2,400
Yueliangtian	600
Shanjiaoshu	450
Laowuji	900
Huopu	2,400
Jinjia	1,800
<b>Total</b>	<b>8,550</b>

**Table 3. The Production Plan for Panjiang Mining Area ( $10^3$  t/a)**

<b>Coal Mine</b>	<b>2005</b>	<b>2010</b>	<b>2015</b>
Active Mines			
Huopu	2,400	2,400	2,400
Yueliangtian	900	900	900
Shanjiaoshu	900	900	900
Laowuji	1,200	1,200	1,200
Tucheng	2,400	2,400	2,400
Jinjia	1,800	1,800	1,800
Planned Mines			
Xiangshui	1,000	4,000	10,000
Songhe		1,800	1,800
<b>Total</b>	<b>10,600</b>	<b>15,400</b>	<b>21,400</b>

PCPGC is one of the 520 largest enterprises in China. Since the government has not restricted coal prices since 1993, company profits have been going up year by year. In recent years, affected by the weakened coal market, profits decreased to some extent. However, the yearly average profit has remained around 10 million yuan. In 1999, total assets of the enterprise reached 3.96 billion yuan. Raw coal output was 4.92 million t, maintaining profit for 7 successive years. Total accumulated profits have been up to 225 million yuan, qualifying PCPGC as a “AAA” grade enterprise in bank qualification and credit.

### 3. Coalbed Methane Resources

The overall geologic structure in the Panjiang mining area is complicated, but the structure within each mining field is simple. Coal-bearing strata in the mining area belong to the Upper Permian Longtan formation, generally containing 40 to 50 and more layers of coal. Total thickness of the coal seams ranges from 20 to 40 m. There are 12 to 22 recoverable and partly recoverable coal seams, of which 6 to 12 seams are recoverable. Thickness ranges from 16 to 27 m. The interburden between coal seams is small, generally 5 to 12 m (Figure 1). Permeability is not high for most of the recoverable coal seams, which makes gas recovery difficult. However, according to the experience of PCPGC, when coal seams have been relaxed

by coal mining their permeability usually increases, and coalbed methane recovery becomes easier. Daily gas production for a single well in the relaxed zone can reach 30,000 m<sup>3</sup>/d or more.

Coalbed methane resources in the mining area are described in Tables 4 and 5.

**Table 4. Coalbed Methane Resources in Panjiang Mining Area**

Parameter	Quantity
Depth of Coal Seams	shallower than 500 m
Major Coal types	medium volatile matter bituminous coal
Gas Content	10-20 m <sup>3</sup> /t
Permeability of coal seams	up to 1.67 md
Coalbed Methane Resources	124.24 billion m <sup>3</sup>

**Table 5. Coalbed Methane Resources in the Mining Fields**

Name of Mining Field	Producing Mines	Careful Survey Mining fields	General Survey Mining fields	Total
Quantity of Mining Fields	6	7	15	28
Coalbed Methane Reserves(billion m <sup>3</sup> )	24.48	40.11	59.68	124.3

The above-calculated coalbed methane resources exclude those within surrounding strata and gob areas of the producing mines. Total resources are likely to be lower than actual resources. It is estimated that the prospective resources could be more than 200 billion m<sup>3</sup>.

#### 4. Current Status of CMM Recovery and Utilization

The Panjiang mining area has 6 operating mines, of which 3 mines are gassy and outburst mines and other 3 are high gassy mines. A well-equipped CMM recovery system has been established at each coal mine. In 2000, methane emissions from the Panjiang mining area reached 205 million m<sup>3</sup> and coal production amounted to 500 Mt.

Panjiang mining area has 10 pump stations used for gas recovery, and 35.3 km of pipelines. There are two sets of recovery systems at high and low negative pressure, respectively. CMM recovery over the past few years in the Panjiang mining area is shown in Table 6.

**Table 6. CMM Recovery in Panjiang mining area From 1996 to 1999** Uint: ×10<sup>3</sup> m<sup>3</sup>

year	Laowuji Mine	Shanjiaoshu Mine	Yueliangtian Mine	Tucheng Mine	Huopu Mine	Total
1996	3,960	2,710	7,910	4,050	-	18,630
1997	8,100	1,590	12,330	7,010	-	29,030
1998	14,240	4,170	9,350	7,830	760	36,350
1999	11,760	7,200	8,300	6,840	3,680	37,780
2000	14,240	7,160	10,000	8,900	2,260	42,560

The existing recovery method in Panjiang mining area is mainly based on the production safety



of coal mines. Only one in-mine drainage method is used, so the efficiency of gas recovery is only 25%. If an advanced recovery method is adopted, and the gas recovery is combined with development, there would be no need to equip additional recovery facilities; using existing recovery equipment, the annual methane production could reach more than 150 million m<sup>3</sup>. According to geological and borehole data from the coal mines, if a comprehensive method which combines surface drilling with in-mine pre-drainage from producing mines is adopted, the annual CMM output could be higher than 500 million m<sup>3</sup>.

The Panjiang mining area started preparing for setting up CMM household use projects in 1986. In 1998, two CMM town gas systems were established in the Shanjiaoshu and Yueliangtian Mines, and a 10,000 m<sup>3</sup> gas storage tank and related safety equipment was installed in the two mines, respectively. In 1999, just 1.95 million m<sup>3</sup> of methane was utilized.

Based on the current status of coal mining, the development plan in each coal mine, the test results of CMM recovery by surface boreholes drilled into released zones, if comprehensive CMM drainage is performed, the capacity of gas recovery and service life of the Laowuji, Shanjiaoshu, Yueliangtian, Tucheng, Huopu and Jinjia Mines can be estimated and is shown in Table 7. If the recovered CMM can be sold at 0.1yuan/m<sup>3</sup>, the PCPGC will be willing to invest in the gas recovery systems by their own money, and the investment will not be included in the budget of the following gas use projects, but included in the budget of mine safety projects.

**Table 7. Stable CMM Production at Each Mine of Panjiang Mining Area**

<b>Mine</b>	<b>Stable CMM production (Pure methane, m<sup>3</sup>/min)</b>	<b>Service Life (years)</b>
Laowuji	45	55
Shanjiaoshu	15	55
Yueliangtian	20	55
Huopu	10	180
Jinjia	15	180
Tucheng	17	162

## **5. CMM Comprehensive Utilization Project**

### **5.1 Project Description**

The Panjiang mining area is located in the south part of Guizhou province where there are no conventional natural gas resources. Coal is a commonly used fuel for residents in the mining area and nearby small cities. Coal is also used as fuel by the local small power stations, which results in serious pollution to the environment. The purpose of the project is to fully take advantage of the existing facilities for obtaining maximum profits, to completely recover the drained CMM and supply it to the residents in the mining area through pipelines, and to supply the Laowuji power plant and the two planned CMM power plants. CMM supplied to the power plants will substitute for medium heating value coal and the diesel used for ignition.

**Table 8. Gas Supply Capacity of Sub-project (pure methane)**

Sub-project Name	Methane Recovery (m <sup>3</sup> /min)	CMM used (m <sup>3</sup> /d)	Supply Capacity (m <sup>3</sup> /d)
Laowuji-Shanjiaoshu-Yueliangtian	105	10,200	141,000
Huopu-Gangouqiao-Hongguo	35	0	50,400
Tucheng	17	0	24,480

According to the existing coal mines, the distribution of residential buildings in the mining area, and the development plan, the CMM comprehensive utilization project for the production mines in PCPGC will be divided into three sub-projects, i.e., the Laowuji-Shanjiaoshu-Yueliangtian sub-project, Huopu-Gangouqiao (where the PCPGC headquarter is located)-Hongguo sub-project, and Tucheng sub-project. The capacity of gas supply for each sub-area is shown in Table 10.

Based on the statistics, there are 59,200 household users in Panjiang mining area. The daily demand for the pure methane is 59,200 m<sup>3</sup>. The coal refuse power plant in the Laowuji Mine consumes 63,442 m<sup>3</sup> of pure CMM per day. CMM demand for each sub-project is as shown in Table 9.

**Table 9. Gas Consumption of Users in Sub-project**

Sub-project Name	Pure Methane Consumption (m <sup>3</sup> /d)	Percentage (%) Accounting for Gas Supply
Laowuji-Shanjiaoshu- Yueliangtian	71,549	50.74
Huopu-Gangouqiao-Hongguo	48,825	96.88
Tucheng	8,400	34.31
<b>Total</b>	<b>128,774</b>	<b>59.65</b>

Since the daily gas consumption of users in the sub-areas of Laowuji-Shanjiaoshu- Yueliangtian and Tucheng accounts for a small percentage of the daily gas supply, PCPGC is planning to set up two CMM power plants, one at the Laowuji Mine with an installed capacity of 9 MW, and another will be at the Tucheng Mine with an installed capacity of 2 MW. Daily CMM consumption of the two power plants will be 64,800 m<sup>3</sup>/d and 14,400 m<sup>3</sup>/d respectively.

This project is scheduled to start implementation by the end of 2001, and the construction period will be two years. Total investment for the project is 112 million yuan, of which fixed assets investment will be 108.22 million yuan, and the working capital 3.78 million yuan (see Table 12). The enterprise plans to raise 35% of the project total investment, and the other 65% will come from the loan to be applied from financial organizations concerned. At present, the Economic and Trade Commission of Guizhou province has provided to PCPGC 35 million yuan of the preferential loan (the actual interest of the loan is zero). The rest is expected to come from commercial loans or overseas investment.

## 5.2 Financial Analysis

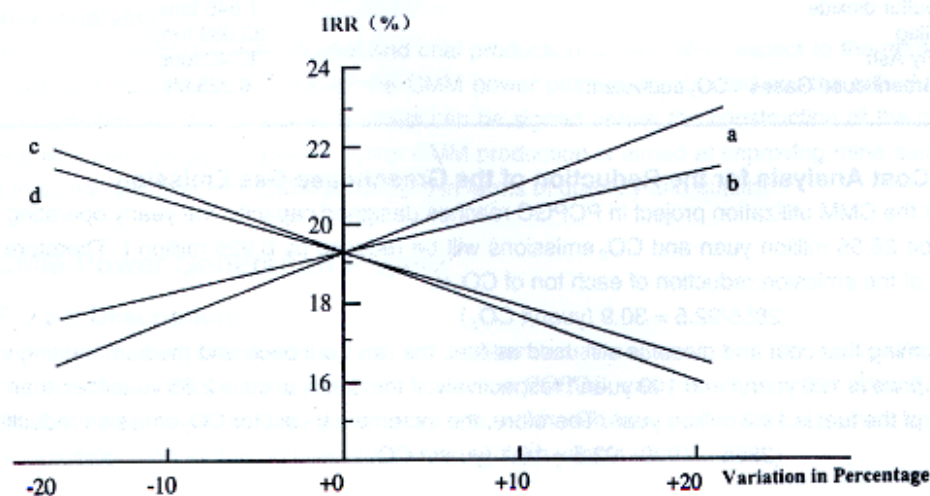
In accordance with the market study, the CMM price acceptable to residential users in the Panjiang mining area is 0.5 yuan/m<sup>3</sup> (CH<sub>4</sub> concentration 45%). The gas supply price at the mine

mouth that can be acceptable to PCPGC is 0.1 yuan/ m<sup>3</sup> (CH<sub>4</sub> concentration 45%). The financial analysis of the project uses discounted cash flow methods. The main financial assumptions include: real discount rate 12%, inflation rate 3%, exemption of income tax for the first 5 years. After calculation, the results of the project economic evaluation are as shown in Table 10.

**Table 10. Results of Economic Evaluation**

Item	Quantity
Designed Gas Supply (10 <sup>6</sup> m <sup>3</sup> /d)	181
Total Investment (10 <sup>6</sup> yuan)	112.0
Annual Sales Tax (10 <sup>6</sup> yuan)	9.0
Annual Sales Profit (10 <sup>6</sup> yuan)	21.2
Financial Internal Rate of Return (total investment, %)	19.33
Financial net present value (ic = 12%, 10 <sup>6</sup> yuan)	42.9
Payback Period (years)	6.04

The following factors may vary during the calculation for the project: sales price, gas supply amount, total investment and operating cost. Results of the sensitivity analysis for the variation of each factor are shown in Fig.2. The results indicate that this project would be highly profitable and the variation of CMM sales price would have the largest influence on the economic results of the CMM project.



**Fig.2 Sensitivity Analysis Curve**

### 5.3 Analysis of Energy Savings and Emission Reduction

When put into operation, the project will provide CMM as fuel for household use in the mining area and Laowuji coal refuse power plant and CMM power plant. The following benefit analysis for energy savings and environment protection excludes the CMM power plant because it will be considered as a separate project.

According to calculation, CMM using as fuel for household can save 121,000 t of raw coal. In

the Laowuji coal refuse power plant, CMM can save 43,500 t of medium heating value coal and 100 t of diesel with a heating value of 46 MJ/kg per year. As a result, SO<sub>2</sub> emission was reduced by 1,646 t, slag discharge was reduced by 33,089 t and fly ash 1,742 t.

The project also recovers 44.77 Mm<sup>3</sup> (31,800 t) CMM emissions annually, which is equivalent to the reduction of 0.667 Mt of CO<sub>2</sub> emission. As to CO<sub>2</sub> emission reductions from the project due to combustion, the combustion of 44.77 Mm<sup>3</sup> of CH<sub>4</sub> would emit 82,000 t of CO<sub>2</sub> annually, in contrast, consuming 121,000 t of raw coal, 43,500 t of medium heating coal and 100 t of diesel would emit 340,000 t of CO<sub>2</sub>. Thus, the actual reduction in CO<sub>2</sub> emissions would be 0.925 Mt of CO<sub>2</sub>. Table 11 summarizes the environmental benefits of the project.

**Table 11. Emissions Reductions of CMM Power Generation Project**

Type of Emission	Amount Reduced Annually
Sulfur dioxide	1,646 tons
Slag	33,089 tons
Fly Ash	1,742 tons
Greenhouse Gases (CO <sub>2</sub> equivalent)	0.925 Mt

#### 5.4 Cost Analysis for the Reduction of the Greenhouse Gas Emission

After the CMM utilization project in PCPGC reaches designed capacity, the yearly operating cost will be 28.55 million yuan and CO<sub>2</sub> emissions will be reduced by 0.925 million t. Therefore, the cost of the emission reduction of each ton of CO<sub>2</sub> is:

$$2855/92.5 = 30.9 \text{ (yuan/t CO}_2\text{)}$$

Assuming that coal and diesel is still used as fuel, the raw coal price and medium heating value coal price is 120 yuan/t and 100 yuan/t respectively; if the diesel price is 2.65 yuan/liter, then total cost of the fuel is 19.2 million yuan. Therefore, the incremental cost for CO<sub>2</sub> emission reduction is

$$(2855 - 1920) / 92.5 = 10.1 \text{ (yuan/t CO}_2\text{)}$$

#### 5.5 Major Barriers to Project Implementation

##### 1) Lack of Successful Demonstration Projects

Although coalbed methane development and utilization is going up rapidly in China, there has been little economic result for coalbed methane utilization projects for various reasons, for example, gas price is controlled by local government not by market.

##### 2) Lack of Funds

In recent years, due to the weakened coal market, the economic results of PCPGC were not as good as before. So it is difficult for the enterprise itself to contribute enough money to CMM projects. Therefore, a portion of the funding must come from outside the enterprise.

#### 5.6 Project Requirements and Existing Conditions

This project requires the participation of investors. Total investment in the project will be as high as 112 million yuan. Approximately 49 million yuan of the loan will be needed to fill the funds shortage. The interest rate of the loan should be lower than 8%. The participation of external

investors will not only solve the problem of the funding shortage, but also enhance the confidence of the high-level leaders of PCPGC.

The existing conditions for the project implementation are as follows:

- 1) The Panjiang mining area has abundant CMM resources and good conditions for CMM development;
- 2) The Government of Guizhou province fully supports the project and has provided 35 million yuan of the preferential loan;
- 3) Two small-sized household use CMM utilization system have been established in the Shanjiaoshu and Yueliangtian Mines. They have accumulated solid technical experience in the construction of CMM transport and distribution facilities, and in the management of CMM recovery pump stations.
- 4) Marketing of the CMM will be mainly conducted within PCPGC, and the CMM market will be ensured.

## **5.7 Risk Analysis**

The project risk mainly involves market and coal production issues. With respect to the market, profitability will be depend on whether the CMM power plant is constructed at the scheduled time and whether the gas purchase contract can be signed before the construction of the coal refuse power plant project is started. Since CMM production is aimed at improving mine safety, coal production will affect the CMM production in terms of quantity and quality.

## **6 CMM Power Generation Project**

### **6.1 Project Description**

PCPGC has two power plants, and the electricity generated averages around 100 million kWh. In the past two years, annual power consumption of the PCPGC was over 300 million kWh. Each year as much as 200 million kWh of electricity was purchased from the power grid, which spent nearly 70 million yuan for the purchase of electricity each year.

According to the gas consumption for each sub-area described in Section 5, besides the CMM recovered from Panjiang mining area supplying to the residents, the surplus gas is sufficient for setting up a 9 MW and a 2 MW CMM power plant at the Laowuji and Tucheng Mines respectively.

Based on annual average operating time of 7,200 hours for power generating equipment, the annual electricity generated from two CMM power plants will be 79.2 million kWh, plus the annual 100 million kWh of electricity generated from the previous power plant. The capacity of annual power supply at PCPGC is still less than 60% of its annual power consumption, which conforms to the stipulation by the power grid that the power supplied by a user itself is not allowed to exceed 70% of its total power consumption.

This project is scheduled to import 11 gas-fired power generation units. Total installed capacity is 11 MW. Yearly power generation will be 79.2 million kWh consuming 23.76 million m<sup>3</sup> of pure



methane. The service life of the project is 20 years.

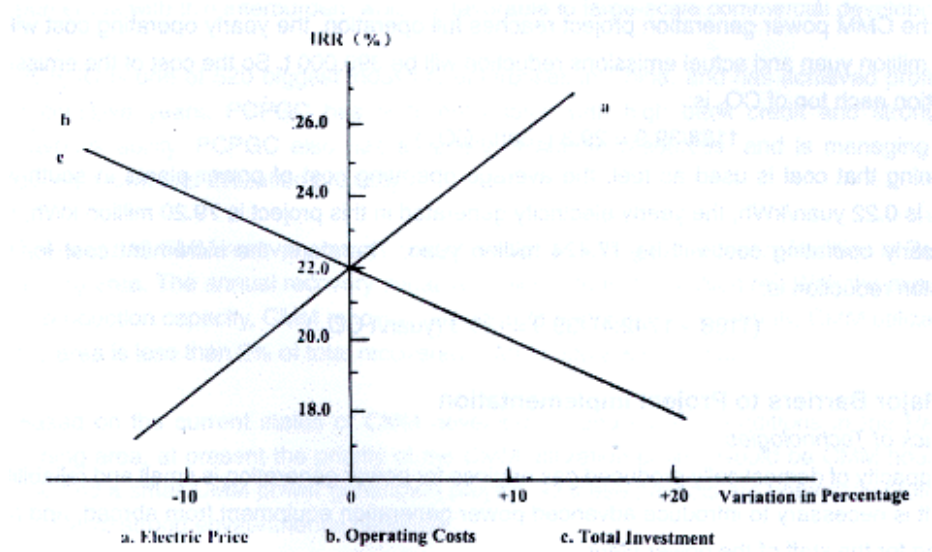
The results of economic and technical evaluation of the CMM power plant are shown in Table 12.

**Table 12. Results of Economic & Technical Evaluation for CMM Power Plant**

Item	Unit	Quantity	Remarks
Installed Capacity	MW	11	
Electricity Generated	$10^6$ kWh/a	79.2	Yearly Operating 7200 Hours
Suppliable Power	$10^6$ kWh/a	73.26	Exclude 6% self-used power And 1.5% line loss
CMM Consumption	$10^3$ m <sup>3</sup> /a	237.6	Pure Methane
Standard Gas Consumption	m <sup>3</sup> /kWh	0.3	
Construction Period	month	6	
Total Investment	million yuan	75.00	
Investment per unit	yuan/kW	6818	

## 6.2 Financial Analysis

Total investment in the project is 75 million yuan, of which 35% will be used as equity to be raised by the enterprise itself. The remaining 65% of the funds (48.75 million yuan) are expected to come from the loan provided by financial organizations. Assuming the interest rate of the loan is 6%, the interest during the construction is 1.46 million yuan. Thus, the total amount of the loan is 50.21 million yuan.



**Fig.3 feasibility Analysis Curve**

Discounted cash flow methods are used to analyze the capability for profitability of the CMM power plant project. The basic financial assumptions include a real discount rate of 12% and inflation factor of 3%. After the project is put into operation, the income tax rate will be 0 for the first 5 years, after which the income tax rate is 33%. The electricity generated in this power plant will be utilized by the enterprise itself. Assuming that the electricity price is same as the local price of 0.34 yuan/kWh, and the CMM (CH<sub>4</sub> 45%) price is 0.3 yuan/m<sup>3</sup>, the results of the

preliminary economic evaluation for the CMM power plant are shown in Table 13. The sensitivity analysis of the project is based on the investment per kW, power price on sale and operation cost (Fig.3). The results indicate that this project would be highly profitable. The electricity price variation is the factor that affects profitability the most.

**Table 13. Results of Economic Evaluation for CMM Power Generation Project**

Item	Quantity
Total Investment	75 million yuan
Scale	11 MW
CMM (CH <sub>4</sub> 45%) Price	0.3 yuan/m <sup>3</sup>
Electricity Price	0.34 yuan/kWh
Methane Consumption	23.76 million m <sup>3</sup> /a
IRR	22%
NPV	23.29 million yuan
Pt	7 years

### 6.3 Analysis of Energy Savings and Emission Reduction

When put into operation, the power plant will consume 23.76 Mm<sup>3</sup> of CMM annually. Currently, PCPGC' s coal fired power plant has a heat rate of 0.5kg/kWh, therefore the CMM power plant can save 39,600 t of coal per year.

Pollutant emissions can be reduced remarkable by using CMM instead of coal to generate electricity. The heating value, sulfur content and ash content of raw coal produced in Panjiang mining area is 6000 kcal/kg, 0.5% and 18% respectively. As a result, electricity generation using CMM can correspondingly reduce 198 t of SO<sub>2</sub>, 6772 t of slag, and 356 t of fly ash.

The project also recovers 23.76 Mm<sup>3</sup> (16,900 t) of CMM emissions annually, which is equivalent to emissions reduction of 355,000 t of CO<sub>2</sub>. As far as the project resulting in CO<sub>2</sub> emission reductions is concerned, this project will burn 23.76 million m<sup>3</sup> of CH<sub>4</sub>, emit 43,700 t of CO<sub>2</sub>. However, if coal is used as fuel, then 39,600 t of coal would be needed and 87,800 t of CO<sub>2</sub> would be emitted. Therefore, this project will reduce CO<sub>2</sub> emission by 390,000 t. Table 14 summarizes the environmental benefits of the project.

**Table 14. Emissions Reductions of CMM Power Generation Project**

Type of Emission	Amount Reduced Annually
Sulfur	198 t
Slag	6,772 t
Fly Ash	356 t
Greenhouse Gases (CO <sub>2</sub> plus CH <sub>4</sub> expressed in terms of CO <sub>2</sub> equivalent)	0.399 t

### 6.4 Cost Analysis for the Reduction of the Greenhouse Gas Emission

After the CMM power generation project reaches full operation, the yearly operating cost will be 11.88 million yuan and actual emissions reduction will be 399,000 t. So the cost of the emissions reduction each ton of CO<sub>2</sub> is:

$$1188/39.9 = 29.8 \text{ (yuan/t CO}_2\text{)}$$

Assuming that coal is used as fuel, the average operating cost of power plants in south-west

China is 0.22 yuan/kWh, the yearly electricity generated in this project is 79.20 million kWh, then the yearly operating cost will be 17.424 million yuan. Therefore, the increment cost for CO<sub>2</sub> emission reduction is:

$$(1188 - 1742.4) / 39.9 = -29.3 \text{ (yuan/t CO}_2\text{)}$$

## **6.5 Major Barriers to Project Implementation**

### *1) Lack of Technologies*

The capacity of domestically produced gas engines for power generation is small and reliability is poor. It is necessary to introduce advanced power generation equipment from abroad, and have training for the staff of the power plant.

### *2) Lack of Funds*

The investment of 75 million yuan is needed for the project. It is difficult for PCPGC to fund this amount without outside financing.

## **6.6 Project Requirements and Existing Conditions**

This project requires investors and technology providers as partners. Technology providers are required to provide complete sets of power generation equipment and technology, and training for personnel. Investors are required to input 48.75 million yuan, which can be invested in the form of the equipment lease.

The existing conditions of the project are as follows:

- 1) PCPGC is capable of providing 35% of the necessary funds related to the project and technical staff needed for the project implementation;
- 2) CMM quality and efficient gas supply is ensured;
- 3) PCPGC is a big electricity consumer and will utilize the electricity generated.

## **6.7 Risk Analysis**

The project risk mainly involves two aspects: technology and market. Reliability and adaptability of the electricity generating equipment will have a direct influence on the operation of the power plant. With regard to the market, variation of CMM price and electricity price will greatly affect the profitability of the project.

## **7 Conclusions and Suggestions**

- (1) CMM resources shallower than 500 m in Panjiang mining area are 124.3 billion m<sup>3</sup>. Gas content ranges from 10 to 20 m<sup>3</sup>/t on average with high permeability. Coal seams are numerous with thin interburden, which is favorable to large-scale commercial development.
- (2) PCPGC is one of 520 biggest industrial enterprises in China, and has achieved profit for 7 successive years. PCPGC has sufficient capital with high bank credit and strong loan payback ability. PCPGC also has a variety of human resources, and is managing CMM development and utilization projects.

- (3) There are 10 CMM recovery pump stations equipped with good recovery facilities in

Panjiang mining area. The annual recovery capacity is higher than 150 million m<sup>3</sup>. With the expanding of production capacity, CMM recovery will be further increasing. Currently, CMM utilization in the area is less than 2% of total recovered. CMM supply is sufficient.

- (4) Based on the current status of CMM development and market conditions in the Panjiang mining area, at present the priority of the CMM utilization project would be CMM household use and a small CMM power generation project. All these projects are potentially profitability and have strong environmental benefits. From a long term point of view, CMM produced in the Panjiang mining area could be supplied to household users in nearby large and medium cities, large CMM power plants, and a CMM synthesis ammonia project.
- (5) At present, major barriers of the CMM projects in the Panjiang mining area are lack of successful precedents and lack of funds and technologies. Mainly the risks for project implementation involve the adaptability of new techniques and variation in CMM sales prices.

In order to speed up the development of the CMM industry in the Panjiang mining area, suggestions are made as follows:

- (1) Introducing foreign funds and technologies to speed up the implementation of CMM utilization projects in the Panjiang mining area, and promote the deployment of coalbed methane surface wells.
- (2) Strengthening functions of the management departments in charge of CMM development and utilization, simultaneously managing projects for CMM in-mine drainage and surface drilling development, making full use of the existing resources of the enterprise so as to promote the development and utilization of CMM resources, taking every possible means to increase the environmental benefits and economic results of CMM projects.
- (3) The CMM market development should initially focus on small scale, local projects and gradually be expanded to more distant areas. In-mine drained CMM should be mainly used for households and power generation in the local market. With regard to large-scale surface development, coalbed methane could be used to make chemical products and supplied to surrounding large and medium-sized cities.

## **China Coalbed Methane Clearinghouse**

China Coalbed Methane Clearinghouse (CBMC), which is funded jointly by the former Ministry of Coal Industry, PRC and the US Environmental Protection Agency, was established in August 1994. The Clearinghouse is part of the China Coal Information Institute. The goal of the Clearinghouse is to promote the development of coalbed methane recovery and use projects in China.

The Clearinghouse undertakes a variety of activities, including:

- Providing consulting services to developers, including financial, market, and economic analyses of potential coalbed methane projects;
- Creating a domestic industry network for information exchange and project development and connecting potential developers with these contacts;
- Providing logistic support to representative of foreign organizations visiting China;
- Organizing conferences, workshops and technical seminars;
- Researching and publishing technical documents, including journals and reports;
- Recommending policies on coalbed methane recovery and use to government agencies.

With regard to the US EPA sponsored project Coal Mine Methane Market Development, the Clearinghouse prepares data packages of coal mine methane projects in 8 key mining areas, including Panjiang, Jincheng, Huainan, Huaibei, Fushun, Yangquan, Pingdingshan and Jiaozuo, and disseminate these data packages to interested investors and developers for international technical and economic cooperation in CMM projects. This data package of Panjiang is prepared by Mr. Huang Shengchu, Mr. Xu Huijun, Mr. Zhu Chao and Ms. Liu Xin of the the CBMC, Mr. Lu Hongzhuang and Mr. Yang Ping of the Panjiang Coal & Electric Power Group Co., and reviewed by Mr. Karl Schultz of US EPA and Mr. Chen Fuqing of the Panjing Coal & Electric Power Group Co. The Clearinghouse also acknowledges the input from the Raven Ridge Resources Inc.





Two gas holders have been built in Panjiang mining area, with total storage capacity of 20,000 m<sup>3</sup>.

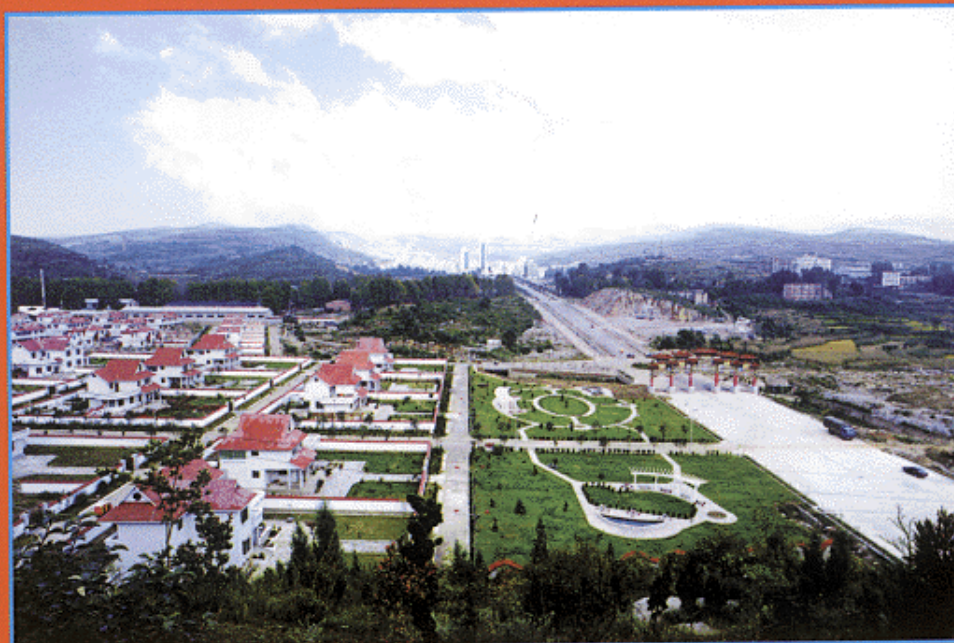


10 gas drainage systems have been constructed, with the total drainage capacity over 150.0 million m<sup>3</sup>/a.

Three surface wells have been drilled in Panjiang mining area, aimed at evaluating the development potential for coalbed methane.







Overview of Panjiang Mining Area

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